

Jurnal Teknologi, 34(E) Jun 2001: 9–24
© Universiti Teknologi Malaysia

MATHEMATICS EDUCATION AT UNIVERSITI TEKNOLOGI MALAYSIA (UTM) : LEARNING FROM EXPERIENCE

YUDARIAH MOHD. YUSOF¹ & ROSELAINY ABDUL RAHMAN²

Abstract. This paper will describe mathematics education in UTM. A review of the problems faced in the learning and teaching of mathematics in the last decade will be discussed. Several academic strategies have been implemented in the past, aimed at overcoming students' learning difficulties, narrowing the abilities gap among the students, as well as facilitating the transition from secondary to tertiary learning. A summary of these programmes will be presented.

There are now changes taking place that will further impact the direction of education in UTM. There is an increase in the number of students intake, a movement towards integrating the use of electronic media in teaching and an expansion of virtual education to ensure a wider access to education. In particular, for mathematics education, these changes will affect the curriculum development, the teaching methods and the assessment of mathematics learning.

Thus the scenario in UTM is set – within the existing academic system, the old problems still persist, approaches have been undertaken and discarded, new strategies implemented periodically and there are now new changes and development to be faced. These experiences must be taken into consideration in order to develop guidelines for future mathematics education in UTM.

Abstrak. Kertas kerja ini akan menerangkan perkembangan pendidikan matematik di UTM. Suatu tinjauan berkaitan dengan masalah pembelajaran dan pengajaran matematik dalam dekad yang lalu akan dibincangkan. Beberapa strategi telah dilaksanakan untuk menangani permasalahan pelajar, mengurangkan jurang perbezaan kebolehan antara pelajar serta memudahkan peralihan dari sekolah ke pendidikan peringkat tinggi. Suatu ringkasan tentang program-program tersebut akan diberikan.

Beberapa perubahan yang berlaku kini akan memberi kesan kepada hala tuju pendidikan di UTM. Terdapat peningkatan dalam bilangan pengambilan pelajar, usaha ke arah menyepadukan media elektronik dalam pengajaran dan pengembangan pendidikan maya yang akan membuka ruang yang lebih luas kepada pendidikan. Khususnya, bagi pendidikan matematik, perubahan ini akan mempengaruhi perkembangan kurikulum, kaedah pengajaran dan penilaian pembelajaran matematik.

Oleh yang demikian, inilah dia senario pendidikan di UTM – dalam sistem akademik yang sedia ada, dengan masalah yang belum selesai, pendekatan-pendekatan yang telah dilaksanakan dan ada yang di ketepikan, strategi baru diperkenalkan secara berkala, dan kini terdapat pula perubahan dan perkembangan baru yang perlu dihadapi. Pengalaman lalu harus dimanfaatkan untuk menyediakan garis panduan bagi pendidikan matematik di UTM pada masa hadapan.

1.0 INTRODUCTION

There have been considerable research identifying students' mathematical difficulties and approaches to learning mathematics at tertiary level (Rees, 1973; Smith &

^{1 & 2} Dept. of Mathematics, Universiti Teknologi Malaysia, 81310, Skudai, Johor Darul Takzim. Malaysia. e-mail: yudariah@mel.fs.utm.my and lainy@mel.fs.utm.my.

Howarth, 1980; Kurz, 1985; Tall & Mohd. Razali, 1993; Harel & Taragalová, 1996; Anthony, 2000). Results from these researches showed that there is a cause for concern on the quality of students' mathematical learning at university. There are now some efforts being made to improve the state of mathematics education and to encourage more dialogue among mathematics educators who are concerned with teaching and research in mathematics at university level. Among the more significant efforts were a series of studies (Howson, 1988; Artigue & Ervynck, 1992; ICMI, 1998) on teaching and learning of advance mathematics which were supported by the International Commission of Mathematics Instruction (ICMI)¹. The most recent study by Anthony (2000), identified several factors that can affect students' success in mathematics such as lecturers' conceptions of both teaching and learning of mathematics, students' prior knowledge and previous learning experiences. In addition, she also found other factors such as, teaching methods, curriculum design, students' learning styles and beliefs, which influenced students' achievement after their entry into the universities.

Studies on students' learning of mathematics at UTM have indicated similar findings identifying several factors that heavily influenced students' success. In this paper we will give a review and an analysis of those factors. This will be followed by a discussion of teaching methods and past strategies taken to alleviate the students' problems. We will also consider current changes that will have an impact on mathematics education and conclude with suggestions for the future.

2.0 REVIEW AND ANALYSIS OF STUDENTS' LEARNING DIFFICULTIES

The data is gathered from various researches carried out in the past decade on UTM's students' learning difficulties. In general, the studies have identified several aspects that contributed to students' learning difficulties. These can be grouped under 4 general headings, namely, (i) the cognitive aspect, (ii) management of learning, (iii) students' attitudes and perceptions and (iv) transition from secondary schools to university. The summary of the findings is as follows.

(i) The Cognitive Aspect (Liew Su Tim & Wan Muhamad Saridan, 1991; Tall & Mohd Razali, 1993; Faridah Abd. Rahman, 1996; Yudariah & Roselainy, 1997).

The minimum mathematics requirement for students entering UTM is a good credit pass in KBSM² Mathematics while a credit pass in Additional Mathematics is con-

¹ ICMI was formed in 1908 but is the official commission of the International Mathematical Union since 1952. It has a number of affiliated study groups, such as, the International Group for the Psychology of Mathematics Education (PME) and International Congress on Mathematical Education (ICME) that support studies dealing with key issues of particular significance to contemporary mathematics education.

sidered an advantage. Thus, the students should have had a collection of basic mathematical skills and knowledge. Findings from research referred here indicated that students' success in learning mathematics at the university depended on their mastery and ability to transfer their prior mathematical knowledge. However, some students found mathematics at the university difficult and had to take the subject repeatedly before passing. Students' difficulties identified were poor understanding of basic concepts, poor computational competence, inability to effectively organise known facts and problems in mastering the mathematical language and symbols. As such, the students did not have effective problem solving skills and showed a tendency to over generalise the usage of particular mathematical procedures. In general, the researchers concluded that there are indications KBSM Mathematics does not provide adequate mathematical background for the learning of advanced mathematics at tertiary level.

(ii) Management of learning (Khyasudeen, A. Majid, Roselainy, Abdul Halim & Mohd. Noh, 1995; Yudariah & Roselainy, 1998)

There are two main areas of concern, students' learning style and understanding of the academic system that seems to influence students' abilities to manage their learning.

- (a) *Students' learning style* – Khyasudeen *et al.*, (1995) conducted an extensive survey on UTM students' study habits, attitudes and motivation, usage of library facilities, lecturers teaching approaches, classroom facilities and other general factors related to personal and social habits. The study involved 3554 students from a total population of 11,000 students. The results of the study indicated that 70% of the students had poor study techniques and did not display the necessary attitudes for studying in the university. For instance, they had poor time management skills, little peer group interactions, used lectures and tutorials ineffectively and had poor note taking skills. A large number of students had poor reading habits, showed no priority in buying books and showed little effort in researching for extra references and other materials. In addition, the students were not utilising available resources fully as indicated by data on the poor use of library and the students support unit which was set up by the University to provide students with peer group and professional counselling.
- (b) *Understanding of the Academic System* – studies and observations had shown that a large number of students did not fully understand the semester system used in the university. They did not know, for example, how the credit points

² KBSM-Kurikulum Baru Sekolah Menengah (Secondary School New Curriculum)

were computed. Thus they could not take what little advantage the flexibility of the system provided. Students also did not understand the implications of continuous assessment. As such they did not put in much effort in their coursework given periodically by lecturers. The coursework was not fully used to consolidate learning and to accumulate scores.

(iii) Students' Attitudes and Perceptions (Mohd. Yusof & Tall, 1994; Yudariah Mohd. Yusof, 1997; Khyasudeen *et al.*, 1995).

Based on these reports, we will highlight students' attitudes and perceptions towards mathematics and life in general.

- (a) *Towards Mathematics.* It was found that students perceived mathematics as a subject wholly consisting of a conglomeration of facts and procedures. It was also reported that students with poor track record in mathematics achievements in the past were over anxious when exposed to new problems and concepts. They would give up easily when faced with difficulties and showed great reluctance in persevering with new ideas and techniques. They showed little cooperation when teaching approaches that required their participation were carried out.
- (b) *Towards Life in General.* The survey by Khyasudeen et al (1995) found that 70% of the students claimed to have high motivation towards their learning. However, this was not reflected in students' behaviour. Responses from the section on study habits showed that they have poor class attendance, do not have complete lecture notes, and do not participate often in class or peers group discussion. In many cases, a student repeating a subject would continue skip classes and do not make any attempt to discuss his problems with the concerned lecturer. Most of them were also unable to build an effective working relationship with their peers and lecturers. These students faced many difficulties especially when a project or coursework is to be done as a group.

(iv) Transition from Secondary Schools to University

An added difficulty for the students in the first year, is the change of learning and living environment. These difficulties have also been observed in first year students at other institutions (Wood, 1998). Among the major changes faced by UTM students are:

- (a) *Transition from the school term system to the semester system at the university.* In schools, students had two years to prepare for the major examination. However, in the semester system, these students have to assimilate their learning in

- a much shorter period of 15 weeks. They have to face a major examination after 15 weeks of learning.
- (b) *Changes to the classroom setting.* Students could get more individual attention in school as usually there were about 40–50 students in a class. However, in the first year, they have to adapt to the anonymity of being in large groups in lecture theatres and normally, lecturers would not be able to give them individual attention.
 - (c) *Changes to the social environment.* For most students, life in a university campus would be a major change to their lifestyles. They have to adjust not only to changes in the learning environment but also to their new surroundings, physically and socially.
 - (d) *Change of teaching methods.* In schools, students were used to learning mathematics by rote and with intensive guidance from teachers. In the university, they have to be independent learners, cope with the fast pace of learning and work very hard to keep abreast of the subject. The students have to find the time to organise their notes and make extra references on their own.
 - (e) *Changes in the presentation of mathematical content.* School mathematics emphasised on the synthesis of knowledge, starting from simple concepts, building up from experience and examples to more general concepts. The teaching was mainly focused on procedures and manipulation skills as it was aimed at preparing students for the national examinations. However, at university, the teaching of mathematics usually begins with the presentation of theory, moving to general abstraction and making deductions from the theory to apply in a wide variety of specific contexts. Thus, the emphasis of teaching is on the analysis of knowledge.

Faced with such a multitude of factors that could affect the learning of mathematics, it will not be easy to implement teaching initiatives to overcome the problems. However, over the years, UTM had conducted different programs and strategies in attempts to alleviate the problems. Some of these difficulties still persist and in order to develop more effective measures to overcome the problems, we must learn from these experiences. To develop guidelines for future mathematics education in UTM, there is a need to take into consideration experiences of other institutions as well. A brief description of teaching mathematics at UTM and a summary of several of the previous programmes will be given below.

3.0 MATHEMATICS TEACHING STRATEGIES

Students' academic development is considered very important in UTM and various teaching and learning strategies have been implemented to ensure students' success. The following discussion will highlight some of the strategies taken and the teaching

methods employed in the past ten years. Almost all of the teaching methods listed are still currently practised in UTM.

(i) Teaching Methods

The main teaching methods normally used are:

- (a) *Lectures.* Due to the large number of students (between 70–240) in a given course and the amount of materials to be taught, lecturers are usually constrained by time. Thus, the lecture method is considered to be the most suitable mode of delivery of knowledge. The subject would be presented from theory to applications with little teaching innovation or creativity. This pedagogical approach also emphasised more on procedures and computations. Such lectures surely cannot take into account differences in students' cognitive ability and skills development.

Khyasudeen et al. (1995) claimed that 50% of the students rated lecturers as not being able to teach well. The main complaints were that the teachers lacked communication skills and were not able to present interesting lectures. Generally teachers of mathematics received the most criticism about their teaching skills.

- (b) *Tutorials.* Tutorials are meant to support lectures and should be conducted in small groups. However, the number of students involved is usually large, between 30–60 students. In addition, some students did not see the importance of the tutorial sessions and usually skip these classes.
- (c) *Course Module.* The modular approach was said to encourage self-paced and independent learning. Reports have claimed that it provided better learning opportunities compared to conventional instructional methods (Ghalot, 1996). Most mathematics courses in UTM have modules. However, there is no particular body responsible for monitoring the quality of content and its presentation for mathematics.

(ii) Assessment of Learning

Students are assessed continuously based on their coursework and final examinations. The coursework was in the form of quizzes, test or assignments, which carried at least 50% of total marks. On the other hand, the final examination carried not more than 50% of the total marks. Lecturers recognised the importance of assignments in the learning process. However, due to the large number of students in a given class and in order to keep marking to a manageable level, some lecturers resorted only to tests as a means of assessment.

(iii) Various Remedial Strategies

Within the last decade, UTM has tried out several different strategies to overcome the problems mentioned above. Among these were:

- (a) *Remedial Centre* (1987–1990). It was set up as a ‘walk in’ centre by the Faculty of Science. The centre was manned by a group of lecturers who took turns to attend to the students’ needs. It catered for three foundation subjects, namely, Physics, Chemistry and Mathematics. There are two categories of students who used the centre: those who were sent in by their respective lecturers and others who came on their own. However, the centre ceased operation in 1990.
- (b) *Pusat Pengajian Tahun Satu* (Centre for First Year Studies; PPTS Annual Report, 1993/94). This centre was set up in July 1992. It accommodated all first year students from the different faculties except the Faculty of Built Environment. Its main objective was to overcome students’ weaknesses in their foundation subjects namely Mathematics, Science subjects and English. It took a holistic approach in addressing the students’ problems focussing on academic and personal aspects. Students would spend an academic year at the centre before continuing in their respective faculties and this provide them with time to make the transition from secondary to tertiary education.

According to published reports of students’ results, the centre was successful in addressing most of the students’ problems. However, the centre was closed in 1996.

- (c) *Extra Classes*. There were two forms of extra classes. One was conducted by lecturers at their discretion to meet students’ demands and the other, was organised by the Mathematics Department for low achieving students, for whom, attendance was compulsory. However, it was surprising to note that attendance was usually very poor in both types of classes. The usual excuses given by students were that these classes normally coincided with other extra curricular activities. Nevertheless, this method is still widely practised in order to help students with difficulties.
- (d) *Personal Tuition*. This is usually carried out at the discretion of lecturers at students’ requests or suggested by lecturers for weak students. This however, can only cater to a small number of students.

Several changes are now taking place, such as, an increase in the number of full-time student intake, introduction of long-distance and part-time education, increased staff’s workload and more demands on available facilities. In addition, the move towards teaching using the electronic medium will influence the implementation of the mathematics curriculum and the way it is presented. In the following section, we will discuss issues related to some of the changes that have or will take place in the near future.

4.0 CHANGES AND IMPLICATIONS

UTM's policies concerning student's intake and lecturers' performance has had an inadvertent effect on mathematics education. A brief discussion of these policies, other factors and implications arising from them will be presented as follows.

- (i) **Increased Number of Student Intake.** The recent intake in 1998 for Engineering and Science students total nearly 3,000. With increased number of students in a class, lecturers have to conduct large group lectures and tutorials. This has become a major challenge in implementing the mathematics curriculum and consequently, it is also more difficult to conduct the necessary formative assessment especially for first year students taking service courses in mathematics. Discussions carried out to explore suitable teaching approaches to large groups have not arrived at any satisfactory conclusion.
- (ii) **The Inability of Present Physical Facilities to Support the Large Number of Students.** In general, the existing facilities in UTM were not designed for teaching large groups. Lecturers and students have to bear with an uncomfortable and unfavourable teaching and learning environment. For instance, in some cases, the seating arrangements for students were very cramped, the size of some of the whiteboards in classrooms and lecture theaters were too small and this in turn posed problems for students to see whatever was written on the boards. Supporting teaching equipment, for example, Overhead Projectors, Overhead Video and Public Address System becomes necessary. Not all classrooms are equipped with such instruments. If provided, they are poorly maintained and sometimes are inappropriately located in the classroom. There are now efforts being carried out to improve the current situation with respect to the size of classrooms and the facilities provided.
- (iii) **Professional Development Demands.** UTM has determined that all academic staff must focus their efforts on seven main areas for professional development: teaching and learning, research and development, consultation, publication, students' development, management and service to the community. This requirement adds extra pressure on staff who must now balance their heavy teaching workload with other activities for career advancement.
- (iv) **Difference Modes of Learning.** Several modes of learning are now available such as full-time, part-time and distance learning. This has widened access to higher education. Consequently, there is greater diversity in students' academic background and mathematical abilities. To teach effectively, lecturers should take into account the students' background, mode of learning, develop relevant teaching materials, select appropriate teaching styles and implement suitable assessment methods.
- (v) **E-Learning.** By the year 2000, UTM will be integrating the use of electronic media and heading towards virtual education. This will have a substan-

tial impact on the mathematics curriculum, the way it is presented and taught. In addition, more schools will also be implementing this style of learning and future intakes into the university will consist of very competent computer literate students. The setting up of the infrastructure and production of suitable materials is in progress but this must be done more vigorously to anticipate future needs.

- (vi) **Curriculum Issues.** In recent years, there was an unprecedented development of mathematical methods into new areas of application, ranging from biology to finance, from agriculture to neuroscience. There is a need for mathematics education at higher level to reflect the intensive development in the use of mathematics. However, these changes seems to have had no impact on current undergraduate mathematics curriculum (Steen, 1998) which still follows closely topics developed in the 19th century. Thus, there is a need to review the current curriculum in view of new skills required for the development of science and technology in the country.

5.0 DISCUSSION AND SUGGESTIONS

The two main components of mathematics education are teaching and learning. Suggestions given below to improve mathematics education in UTM will be based on these particular aspects.

5.1 Mathematics Teaching

We have identified five major aspects of mathematics teaching that deserves special attention. In the following discussion, each aspect will be considered.

(i) Organisational Considerations

Based on past experience, the less able students have more difficulties in transferring and using their mathematical knowledge attained in school at the university. Thus, they find it difficult to cope with the demands of advanced mathematics. To identify less able students, an on-line diagnostic test with automatic grading can be given to all students upon entry, preferably, in the first week. These diagnostic tests should mainly consist of questions on concepts and mathematical skills in pre-algebra and precalculus that they should have acquired at school level. Using the students' results, course counsellors should advise students to take the route that suits their needs and abilities. Thus, students are allowed to strengthen their basic mathematics through alternative routes. Some of these alternative routes could be:

- (a) *Foundation mathematics in the first year.* Students who were required to strengthen their mathematics should follow a foundation course before enter-

ing the main stream. Those following this option will consequently be one semester behind from their peers. Even though they will be slightly disadvantaged, this will give them more time to enhance their mathematics competencies. The flexibility of the semester system allows for such arrangements.

- (b) *Setting up of mathematics remedial centre.* The setting up of a mathematics remedial centre should be reconsidered as a solution to overcome students' learning difficulties. Low performing students will be required to attend for remedial work throughout the semester. This option will increase student's workload, as at the same time, they still have to attend their normal classes. However, such students need the extra help in order to cope with university mathematics. Either or both of the suggestions deserve further attention to overcome students' weaknesses.

(ii) Mathematical content

The current first year mathematics curriculum is supposedly designed to take into account students' prior mathematical knowledge. However, some studies (Saudah Hanafi, 1996; Yudariah & Roselainy, 1997) indicated that students with poor Additional Mathematics grades or those who did not take the subject, showed poor performance in the first year examinations of Basic Mathematics and Basic Calculus. They were usually in the 50th percentile (grade C-) or lower category. Thus, if UTM maintains its current entry requirements, we would like to suggest the following.

- (a) The first year mathematics must take into account students' mathematical background; those with or without Additional Mathematics. The teaching methods should consider the transition from school to university mathematics. In addition, students should be guided on how to develop suitable learning styles.
- (b) Students should be streamed according to their prior mathematical knowledge or achievement. UTM should provide alternative routes for students with different needs.
- (c) Students without or with weak Additional Mathematics results should follow a foundation course before doing the first year mathematics. Such students will need more time to strengthen their basic mathematics knowledge.

Other issues to be addressed are, firstly, the appropriate mathematics for future needs and secondly, the mathematics for 'e-learning'. First year mathematics should provide the necessary knowledge and competencies to prepare students for advance mathematics and for the mathematics in their own fields of study. Their training in mathematics should also meet the needs and demands of the current as well as future professional practice.

To improve the quality of mathematical knowledge of our graduates in various fields, the following recommendations should be implemented.

- (d) Conduct a study of changes that have taken place at school level and its implications for tertiary learning;
- (e) Carry out an extensive review of the undergraduate mathematics curriculum and its relevance to professional needs;
- (f) Conduct a study of bridging programmes to minimise the difficulties in the transition from school to tertiary mathematics;
- (g) Develop a curriculum that reflects the appropriate use of computer technology in the teaching of mathematics.
- (h) Review mathematical procedures and skills that have to be maintained and those made redundant with the use of the new technology such as graphical calculators, Computer Algebra System, video conferencing and web-based learning.

We realise the above recommendations will be subjected to organisational structures and curriculum constraints, but these have to be resolved for the sake of students' mathematics development.

(iii) Teaching Methods

In order to ensure effective teaching, an environment conducive to mathematics learning must be created. Students must develop the ability to formulate problems, analyse, synthesise and make judgements. However, in most mathematics classes, students' experiences consist of learning routine, repeated and instrumental activities of applying fixed mathematical procedures to collections of structurally identical problems. In addition, based on past experiences of students' shortcomings, lecturers have developed a feeling of detachment to teaching and learning issues (Yudariah, 1995). They are generally reluctant to reorganise teaching materials and they show little consideration for pedagogical issues and cognitive development in mathematics teaching.

Both issues, to reform teaching methods and to change mathematics lecturers' attitudes have to be addressed together. We need teaching methods that will encourage the development of students' mathematical thinking and problem solving skills. In order to initiate and maintain any teaching reform, the lecturers must play an active role in showing the importance and relevance of mathematics. Their enthusiasm will motivate the students to appreciate mathematics more. This could be done through:

- (a) regular discussions among teaching staff on issues related to mathematical content and its presentation;

- (b) keep up with current developments in undergraduate mathematics education and establishing a platform to exchange ideas and experiences with other lecturers.

The above depend on personal initiatives but the organisation should also play its role to encourage the changes. Some of the approaches that can be taken are:

- (c) *Mathematics teaching workshops.* Mathematics lecturers should be required to attend a course or workshop on mathematics teaching that includes methods of delivering mathematical content, how to develop students' mathematical thinking and their problem solving skills.
- (d) *Amenable to suggestions.* The management should be more responsive to suggestions given by lecturers on how to improve the teaching and learning environment.

(iv) Materials development

The educational resources for students' use should include module, textbooks, web-based support materials and links to other learning sites and development of audio-visual instructional materials. In the Mathematics Department, lecturers are encouraged to produce learning modules, write their own text books as well as translate suitable materials into Bahasa Malaysia. However, the content of the learning module should take into account the cognitive development of the students. At the university level, the module must be designed to prepare students for independent and self-paced learning. Therefore, the materials should be self-contained and self-instructional, provide immediate feedback, encourage active participation of the learner and provide self-evaluation strategies. It is necessary to assess the currently available module so as to meet the above criteria and the needs of the students.

In addition, web-based support should be provided to allow students' access to the materials at their convenience and provide for flexible learning. This would be consistent with UTM's movement towards incorporating e-learning culture. Audio materials can further support independent learning of distance and part-time learners.

(v) Assessment

Assessment should focus on the cognitive and affective domains of students' learning. Appropriate assessment techniques must also take into account the large number of students. Thus several different approaches must be considered such as:

- (a) *Students' self-evaluation.* To help students assess their own learning without increasing lecturers' workload, an on-line grading system for quizzes and test-

ing of basic understanding should be made available. This will give students immediate feedback for self-evaluation. In addition, the system could be designed to record students' achievements for lecturers to monitor their students' learning.

- (b) *Assessing the affective domain of students' learning.* Assignments that encourage thinking, writing and communication skills must be given. These should be part of the coursework assessment and could be in the form of projects and group work. Currently, this form of assessment is not popular among lecturers due to time constraints in grading students' work. However, this means of assessment will evaluate the affective domain of students' learning and thus, should be given at least once during the semester.
- (c) *Assessing the cognitive domain of students' learning.* There should be guidelines on what is to be assessed in students' mathematical learning. Examinations and tests are still the main techniques of assessment. The different levels of cognitive development should be considered. We would like to suggest that tests should only include questions that evaluate basic knowledge, understanding and direct applications of the mathematics taught. Examinations, however, should extend the competencies tested to include the ability to analyse, synthesise and make judgements on the problems given.
- (d) *Other forms of assessment.* The ability for students to communicate their mathematical work is important. An approach to be considered would be an extension of group assignments where students are given a collection of problems in a semester to test their problem solving skills and communicate their work in seminars or special presentation session which contribute partially to their coursework.

To improve mathematics teaching, due considerations should be given to the five main aspects discussed above, in particular, course organisation, mathematical content, teaching methods, suitable learning materials and assessment. Together these aspects will contribute to successful teaching of mathematics.

The next section will highlight factors that could determine students' success in mathematics and are based on an analysis of students' views on mathematics learning. Some suggestions for improving students' learning behaviours and learning environment will be presented.

5.2 Mathematics Learning

(i) Enhancing Students' Motivation

In a recent study (Anthony, 2000), students identified self-motivation, appreciation of mathematics and good inter-personal communication skills as important factors in determining their success in mathematics. This is consistent with our own

experiences and it is becoming essential for us to enhance these qualities and help students to adapt to the new learning environment. This can be done through short courses or workshops. We would like to suggest a preparatory course at the beginning of the semester for new students giving them an overview of learning in the university, an understanding of the academic system and how to manage their learning. Students must be shown the importance of utilising university's facilities to support their studies.

In addition, there should be short courses provided on a regular basis to strengthen students' positive attitudes, general study skills and to develop independent learning. Particular attention should be given to the importance of regular class attendance, active attention in lectures, building their confidence, and the need to balance their social and academic life. Currently the students support unit provides personal and academic counselling to students but these services need to be more effective.

(ii) Mathematics Learning Skills

Currently there is no specific programme in UTM to inculcate mathematical learning skills explicitly. Based on research findings (Tall, 1991, Yudariah, 1995), a course to develop students' mathematical learning skills can help in improving students' learning. This course could be held separately or integrated in the mathematics classes. The focus should be on how to read mathematics text, to think mathematically, to develop problem solving ability and to communicate mathematically.

(iii) Course Support

Course support in the form of easy access to lecturers and remedial help were identified as important factors in successful learning (Anthony, 2000). In UTM, due to the large number of students and the heavy demands of students' and lecturers' workload, it is difficult for a lecturer to cater the needs of all his students. An alternative support programme must be provided for example, the setting up of a remedial centre as suggested earlier or a mathematics laboratory.

(iv) Course Organisation, Design and Presentation

Students rated course organisation, its design and how the lectures are delivered as important factors for their success (Khyasudeen *et al.*, 1995; Anthony, 2000). Thus, an environment conducive to mathematical learning appeared to be an important element of effective teaching. Lecturers must improve their inter-personal skills to encourage students' participation and help build good working relationship. In addition, suitable changes to the assessment methods must also be made so as to encourage students to use the learning skills that we wish to instill. However, this requires the lecturers' willingness to change and improve their teaching techniques.

For students to be able to develop mathematical thinking, lecturers must first be conscious of their own thinking and share it with their students. Mathematical ideas and procedures must be made explicit and any misconceptions addressed during teaching.

6.0 CONCLUSION

In this paper we have given a review of mathematics education in UTM. There are on-going measures to improve the quality of course materials, course organisation and the up-grading of existing facilities. Although some progress has been made, there is a need for a more vigorous development to cope with the demands. We need to overcome the current problems and at the same time prepare the academic foundation, infrastructure and the equipment for the move towards technology-enabled education.

There is a need to work out strategies and solutions to overcome students' learning difficulties. Towards this end there must be more coordination and communication between all parties involved. More importantly, efforts should be made to come up with some basic framework on pedagogical and didactical issues that are internationally accepted to ensure the integrity of undergraduate mathematics education in UTM.

In order to bring about the desirable changes in students' learning styles, the lecturers themselves must be willing to provide a suitable environment for these to happen. Therefore, the teaching and assessment methods must be appropriate to the learning objectives we would like to achieve. It is important that students must be motivated enough to want to change.

REFERENCES

- Anthony, G., 2000. Factors Influencing First-Year Students' Success In Mathematics. *Int. Journal of Mathematical Education in Science and Technology*. 31(1).
- Artigue, M. & Ervynck, G. (eds), 1992. *Students' Difficulties in Calculus*, Seventh International Congress on Mathematical Education, Canada.
- Faridah Abd. Rahman, 1996. *Satu Analisis Prestasi Pelajar Tahun Satu Dalam Matapelajaran Kalkulus (An Analysis of First Year Students' Achievement in Calculus)*. Unpublished final year project report, UTM.
- Ghalot, 1996. *Module Writing – An Overview*. Paper presented at Special workshop on Module Writing (Phase III), UNIPEN, UTM, 17 – 23 November.
- Harel, G. & Taragalová, J., 1996. Higher Mathematics Education in Int. Handbook of Mathematics Education, Part Two, Kluwer Academic Publishers, Dordrecht.
- Howson, A. G., 1988. *Mathematics as a Service Subject*. ICMI Study Series. Cambridge: Cambridge University Press.
- ICMI, 1998. Pre-proceedings of ICMI Study Conference on The Teaching and Learning of Mathematics at University Level, 8-12 December, Singapore.
- Khyasudeen, A. Majid, Roselainy, Abdul Halim & Mohd. Noh, 1995. *Kajilidikan Pola Pembelajaran Pelajar UTM (A Survey of UTM Students' Learning Styles)*. UNIPEN, UTM.
- Kurz, G., 1985. Remedial Courses in Mathematics-Scopes and Problems:a Survey for the Federal Republic of Germany. *Int. Jnl of Math. Edn in Sc. and Tech*. 16: 211 – 225.

- Liew Su Tim & Wan Muhamad Saridan, 1991. Ke Arah Memahami Dan Mengurangkan Kesukaran Dalam Pembelajaran Matematik (Towards Understanding and Minimising Students' Difficulties in Mathematics Learning). *Berita Matematik*. 38: 22 – 29.
- Mohd. Yusof, Y. & D. O. Tall. 1994. Changing Attitudes To Mathematics Through Problem Solving. *Proceedings of the 18th Annual Conference on the Psychology of Mathematics Education*, Lisbon. IV: 401 – 408.
- Pusat Pengajian Tahun Satu. 1993/1994. *Annual Report*. UTM.
- Rees, R., 1973. *Difficulties Experienced by Craft and Technician Students*. London: Brunel Further Education Monograph 5, Hutchinson Educational Ltd.
- Saudah Hanafi, 1996. *Satu Analisis Pencapaian Pelajar Tahun Satu Dalam Matapelajaran Matematik Asas (An Analysis of First Year Students' Achievements in Basic Mathematics)*. Unpublished final year project report, UTM.
- Smith, B. J & Howarth, M. J., 1980. Attempts to Identify and remedy the Mathematical Deficiencies of Engineering Undergraduates at Plymouth Polytechnic. *Int. Journal of Mathematical Education in Science and Technology*. 11: 377 – 383.
- Steen. A.S, 1998. Redefining University Mathematics: The Stealth Campaign. *Pre-proceedings of ICMI Study Conference on The Teaching and Learning of Mathematics at University Level*, 8 – 12 December, Singapore.
- Tall, D. O. (Ed), 1991. *Advanced Mathematical Thinking*. Dordrecht, The Netherlands: Kluwer Academic Publisher.
- Tall, D. O. & M. R. Mohd Razali. 1993. Diagnosing Students' Difficulties In Learning Mathematics. *Int. Jnl of Math. Edn in Sc. & Tech*. 24(2): 209 – 222.
- Yudariah Mohd. Yusof, 1995. *Thinking Mathematically: A Framework for developing Positive Attitudes Amongst Undergraduates*. Unpublished PhD Thesis, University of Warwick.
- Yudariah Mohd. Yusof, 1997. Undergraduate Mathematics Education: Teaching Mathematical Thinking Or Product Of Mathematical Thought? *Jurnal Teknologi*. 26(June): 23 – 40.
- Yudariah Mohd. Yusof & Roselainy Abdul Rahman, 1997. *An Assessment Of The Modular Approach In Teaching And Learning First Year Calculus At UTM*. Paper presented at the Conf. on Sci. and Tech. Edn, Kuala Lumpur, 15 – 16 December.
- Yudariah Mohd. Yusof & Roselainy Abdul Rahman, 1998. A Decade of Mathematics Education: A Review and Critical Appraisal of Universiti Teknologi Malaysia's (UTM) Experience. *Pre-proceedings of ICMI Study Conf. on The Teaching and Learning of Mathematics at University Level*, 8 – 12 December, Singapore.
- Wood, Leigh, 1998. *Secondary-Tertiary Interface*, Working Group A1, Pre-proceedings ICMI Study Conference on The Teaching and Learning of Mathematics at University Level, 8 – 12 December, Singapore.